End of the Spectrum

Far-Infrared Spectroscopy Helps Defend Against Threat of Terrorism

Since the tragic events of September 11, 2001, the threat of terrorist attacks on U.S. soil has become a terrifying reality. The government created the Department of Homeland Security to help protect against terrorist threats, and new technologies have been developed to aid in this battle. Of particular importance, is the ability to protect against the threat of chemical and biological warfare agents (CWA/BWA).

Scientists at the National Institute of Standards and Technology (NIST, Gaithersburg, MD) and SPARTA (Rosslyn, VA) have recently developed a novel technique that uses far-infrared (far-IR) or terahertz (THz) radiation to noninvasively detect biological and chemical agents, explosives, and drugs/narcotics inside sealed, nonmetallic containers.

Edwin J. Heilweil of the Optical Technology Division at NIST, and Matthew B. Campbell of SPARTA are two of the scientists who worked on the development of this technology. Heilweil said that the strongest advantage far-IR spectroscopy has is that it is transmitted (noncontact) through most plastics, paper, and materials other than metals. "If one wishes to detect and identify amounts of toxic chemicals or explosive materials in sealed containers made of plastics or paper (possibly glass), or behind nonmetallic walls, then THz spectroscopy is the only currently known method to accomplish this," he said.

The far-IR portion of the spectrum falls between visible light and radio waves and is partially transmitted through many materials. Small-to-medium sized molecules (3–100 atoms) exhibit identifiable spectral features in this portion of the electromagnetic spectrum, and many compounds associated with terrorist threats contain molecules of this size. Therefore, transmission measurements of far-IR light can potentially be used for non-invasive detection of CWA/BWA, explosives, and drugs in the pathway of a THz radiation beam.

The researchers also created a database of spectral characteristics for more than 100 materials, including BWA simulants, CWA simulants, explosives, pharmaceuticals, and potential hoax materials. An Automated Discrimination Algorithm (ADA) tool was developed for identification of THz spectra of bulk materials using the spectral database. The spectrum of a potential threat material is entered into the ADA, which produces a list of materials in the database that match the entered spectrum, ranked from closest match to worst match.

Two different spectrometers, one using a pulsed laser and the other a glowing filament, were used to build the THz spectral database. One of the instruments was a modified Nicolet Magna 550 Fourier transform-infrared (FT-IR) spectrometer (Thermo Electron, Madison, WI). The other instrument was a femtosecond pulsed apparatus. Both instruments are table-top sized and work at room temperature.

The use of far-IR technology for detection of terrorist threats does have some limitations such as radiation throughput. THz radiation does not transmit through metal, and the spectral information that can be collected through glass containers is restricted. However, potential applications for this technology are numerous. Homeland security applications include rapid screening of mail, luggage, or other containers carrying threat materials, as well as biological aerosol detection.

Although this technology is not yet commercially available, Heilweil and Campbell said that they envision that compact modified standard FT-IR spectrometers could be deployed primarily in situations where sealed plastic and small cardboard containers and mail require screening. "They would readily be placed at points of entry in airports and/or customs, as well as mail sorting facilities to complement other technologies when a suspicious parcel passes through these portals. The spectrometer could then quickly assess if a threat is present in the parcel," Heilweil said.

The key benefit of this technology is the detection of CWA/BWA prior to deployment. In this way, far-IR spectroscopy could provide a major advantage in defense against terrorism. ■

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